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Dated: September 20, 2011
Electronic Signature for George W. Neuner: /George W. Neuner/

Docket No.: 66228(302653)
(PATENT)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:
Claus H. Christensen et al.

Application No.: 10/593,519

Confirmation No.: 1406

Filed: February 8, 2007

Art Unit: 1728

For: USE OF AN AMMONIA STORAGE DEVICE
IN PRODUCTION OF ENERGY

Examiner: H. M. Chan

AMENDMENT AFTER FINAL ACTION

MS RCE
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir/Madam:

INTRODUCTORY COMMENTS

Please amend the above application as follows.

Amendments to the Claims are reflected in the listing of claims which begins on page 2 of this paper.

Remarks/Arguments begin on page 9 of this paper.

AMENDMENTS TO THE CLAIMS

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

1 - 20. Cancelled

21 (Currently amended). An electric power generating unit having constituents comprising:

(i) an ammonia storage device in the form of a container comprising an ammonia absorbing and releasing salt of the general formula:



wherein:

M is one or more cations selected from the group consisting of alkali metal, alkaline earth metal, and transition metal ions, or combinations thereof,

X is one or more anions selected from the group consisting of fluoride, chloride, bromide, iodide, nitrate, thiocyanate, sulphate, molybdate, and phosphate ions,

a is the number of cations per salt molecule,

z is the number of anions per salt molecule, and

n is the coordination number of 2 to 12;

(ii) means for heating said container and ammonia absorbing and releasing salt for releasing ammonia gas; ~~and~~

(iii) a reactor for dissociating ammonia into hydrogen and nitrogen; and

(iv) a hydrogen fuel cell for converting hydrogen into electric power;

wherein said means for heating comprises a combustion device wherein a part of the hydrogen produced in the reactor, unreacted hydrogen from at least one fuel cell or a part of the ammonia released from said salt, or a mixture thereof, is oxidized for providing heat for heating the ammonia storage device.

at least one of (iii) an ammonia fuel cell for converting ammonia directly into electric power and (iv) a reactor for dissociating ammonia into hydrogen and nitrogen and a hydrogen fuel cell for converting hydrogen into electric power.

22 (Previously Presented). The electric power generating unit according to claim 21, wherein M comprises a member selected from the group consisting of Li, Na, K, Cs, Mg, Ca, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, NaAl, KAl, K₂Zn, CsCu, and K₂Fe.

23 (Previously Presented). The electric power generating unit according to claim 21 further comprising means for adding ammonia to saturate the ammonia absorbing and releasing salt with ammonia.

24 (Previously Presented). The electric power generating unit according to claim 21, wherein said ammonia absorbing and releasing salt comprises Mg(NH₃)₆Cl₂.

25 (Previously Presented). The electric power generating unit according to claim 21, wherein the salt comprises a powder of microcrystals.

26 (Previously Presented). The electric power generating unit according to claim 21, wherein the salt further comprises a porous support material.

27-28. Cancelled.

29 (Currently amended). The electric power generating unit according to claim 21, wherein the container and means for heating are a part of a micro-size electric system that can be fabricated using a process selected from the group consisting of mechanical grinding, chemical vapour deposition, ~~deposition~~ deposition (CVD), plasma enhanced chemical vapour deposition (PECVD), electron cyclotron resonance (ECR), sputtering, etching and lithography.

30 (Previously Presented). The electric power generating unit according to claim 29, wherein the process is selected from the group consisting of electron beam lithography, photo lithography, or laser lithography.

31 (Previously presented). The electric power generating unit according to claim 21, wherein the reactor for dissociating ammonia comprises a heterogeneous catalyst.

32 (Previously presented). The electric power generating unit according to claim 31, wherein said heterogeneous catalyst comprises a support and an active phase.

33 (Previously presented). The electric power generating unit according to claim 32, wherein said active phase comprises dispersed nanoparticles of transition metals or compounds thereof.

34 (Previously presented). The electric power generating unit according to claim 33, wherein said active phase comprises $\text{Co}_3\text{Mo}_3\text{N}$, Ru, Co, Ni, Fe, or mixtures thereof.

35. Cancelled.

36 (Previously presented). The electric power generating unit according to claim 21, further comprising a combustion device wherein a fraction of the hydrogen produced in the reactor, unreacted hydrogen from one of the fuel cells, or a mixture thereof is oxidized for providing heat for heating said reactor for dissociating ammonia.

37-38. Cancelled.

39 (Previously presented). The electric power generating unit according to claim 21, wherein the constituents thereof are dimensioned to provide full balancing of the complete unit by dimensioning tubes, chambers, flows, insulation and temperatures to obtain optimal output of electrical energy from the electrical power generating unit.

40 (Previously presented). The electric power generating unit according to claim 21, comprising a unit in the form of a micro-size power source for microelectronic devices or micro-electro-mechanical-systems (MEMS).

41 (Previously presented). The electric power generating unit according to claim 21, wherein said reactor for dissociating ammonia is part of a micro-size electric system being that can be micro fabricated using a process selected from the group consisting of mechanical grinding, chemical vapour deposition (CVD), plasma enhanced chemical vapour deposition (PECVD), electron cyclotron resonance (ECR), sputtering, etching and lithography.

42 (Previously presented). The electric power generating unit according to claim 41, wherein said reactor for dissociating ammonia is part of a micro-size electric system being that can be micro fabricated using a process selected from the group consisting of electron beam lithography, photo lithography, or laser lithography.

43 (Previously presented). The electric power generating unit according to claim 21, wherein the reactor for dissociating ammonia is divided into two parts, one part operated at a low temperature that dissociates most ammonia and another part operated at a high temperature that dissociates a last present fraction of ammonia.

44 (Currently amended). A method for producing electrical power, said method comprising:

| (i) providing an ammonia storage in the form of a container comprising an ammonia absorbing and releasing salt of the general formula:



wherein:

M is one or more cations selected from alkali metals, alkaline earth metals, and transition metals, or combinations thereof,

X is one or more anions selected from fluoride, chloride, bromide, iodide, nitrate, thiocyanate, sulphate, molybdate, phosphate, and chlorate ions,

a is the number of cations per salt molecule,

z is the number of anions per salt molecule, and

n is the coordination number of 2 to 12;

(ii) heating said container and ammonia absorbing and releasing salt for releasing ammonia gas;

(iii) dissociating said released ammonia gas into hydrogen and nitrogen in a reactor;

(iv) introducing the dissociated gas into a fuel cell for converting hydrogen into electric power; and

(v) producing electric power;

wherein a part of the hydrogen produced in the reactor, unreacted hydrogen from at least one fuel cell or a part of the ammonia released from said salt, or a mixture thereof, is oxidized for providing heat for heating the ammonia storage device

~~providing means for heating said container and ammonia absorbing and releasing salt for releasing ammonia gas;~~

~~providing (i) a fuel cell for converting ammonia directly into electric power or (ii) a reactor for dissociating ammonia into hydrogen and nitrogen and a fuel cell for converting hydrogen into electric power; and~~

~~producing electrical power.~~

45 (Previously presented). The method according to claim 44, wherein M comprises a member selected from the group consisting of Li, Na, K, Cs, Mg, Ca, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, NaAl, KAl, K₂Zn, CsCu, and K₂Fe.

46 (Previously presented). The method according to claim 44, wherein the electric power generating unit further comprises means for adding ammonia to saturate the ammonia absorbing and releasing salt with ammonia.

47. Cancelled.

48 (New). An electric power generating unit having constituents comprising:

(i) an ammonia storage device in the form of a container comprising an ammonia absorbing and releasing salt of the general formula:



wherein:

M is one or more cations selected from the group consisting of alkali metal, alkaline earth metal, and transition metal ions, or combinations thereof,

X is one or more anions selected from the group consisting of fluoride, chloride, bromide, iodide, nitrate, thiocyanate, sulphate, molybdate, and phosphate ions,

a is the number of cations per salt molecule,

z is the number of anions per salt molecule, and

n is the coordination number of 2 to 12;

(ii) means for heating said container and ammonia absorbing and releasing salt for releasing ammonia gas; and

(iv) an ammonia fuel cell for converting ammonia directly into electric power.

49 (New). The electric power generating unit according to claim 48, further comprising a combustion device wherein a part of the ammonia released from the ammonia storage device, unreacted ammonia from at least one fuel cell, or a mixture thereof is oxidized for providing heat for heating the ammonia storage device.

50 (New). The electric power generating unit according to claim 48, further comprising a combustion device wherein a fraction of the ammonia released from the ammonia storage, unreacted ammonia from at least one fuel cell, or a mixture thereof is oxidized for providing heat for heating said reactor for dissociating ammonia.

51 (New). A method for producing electrical power, said method comprising:
providing an ammonia storage in the form of a container comprising an ammonia absorbing and releasing salt of the general formula:



wherein:

M is one or more cations selected from alkali metals, alkaline earth metals, and transition metals, or combinations thereof,

X is one or more anions selected from fluoride, chloride, bromide, iodide, nitrate, thiocyanate, sulphate, molybdate, phosphate, and chlorate ions,

a is the number of cations per salt molecule,

z is the number of anions per salt molecule, and

n is the coordination number of 2 to 12;

heating said container and ammonia absorbing and releasing salt for releasing ammonia gas;
and

introducing the released ammonia gas into an ammonia fuel cell for converting ammonia directly into electric power.

REMARKS

In the Office Action dated March 25, 2011, claims 21-47 are pending and rejected. A Request for Continued Examination is submitted herewith. Reconsideration is requested at least for the reasons discussed hereinbelow.

The above amendment is submitted to more particularly point out and distinctly claim the subject matter regarded as invention. Support for amended claims 21, 44 and 48-51 can be found particularly in the disclosure on page 18, lines 24 to 29, and in the original claims. New claims 49 and 50 correspond to prior claims 37 and 38.

Applicants submit that the objection to claims 44 and 47 is moot in view of the above amendment.

Claims 21-25, 28, 31, 32, 35-39 and 43-46 are rejected under 35 U.S.C. §103(a) over Goetsch et al. (US 2001/0028171; "Goetsch") in view of Pfister et al. (US 2001/0042378; "Pfister").

The Examiner admits that Goetsch fails to "teach that the ammonia storage device (i) comprises an ammonia absorbing and releasing salt of the general formula: $M_a(NH_3)_nX_z$, wherein: M is one or more cations selected from the group consisting of alkali metal, alkaline earth metal, and transition metal ions, or combinations thereof, X is one or more anions selected from the group consisting of fluoride, chloride, bromide, iodide, nitrate, thiocyanate, sulphate, molybdate, and phosphate ions, **a** is the number of cations per salt molecule, **z** is the number of anions per salt molecule, and **n** is the coordination number of 2 to 12.

The Examiner also admits that Goetsch fails to "teach (ii) means for heating said container and ammonia absorbing and releasing salt for releasing ammonia gas."

The Examiner cites Pfister for the generation and utilization of ammonia gas and a teaching that ammonia is stored in an ammoniated metal salt and for adsorbing and desorbing ammonia gas using heat.

The Examiner concludes that it would have been obvious to one of ordinary skill in the art at the time of the invention to have used the ammonia absorbing and releasing salt such as disclosed in Pfister in the electric power generation unit of Goetsch. The Examiner contends that the skilled artisan would have looked for sources of ammonia and ways to store it in an ammonia storage device of Goetsch and would have appreciated that the metal salts of Pfister provide a solid form of ammonia storage, which means that ammonia can be generated by heating based on demands of the ammonia dissociation reactor and hydrogen fuel cell.

Applicants strongly disagree. Pfister does not disclose or suggest heating a storage container and the solid form of ammonia storage to generate ammonia. Indeed, no actual heating or combustion heating device is disclosed or suggested by Pfister. Instead, Pfister teaches use of microwave energy at substantially **ambient temperature** to release ammonia for a refrigeration system.

One of ordinary skill in the art would hardly consider combining the microwave ambient temperature release of ammonia as taught by Pfister for supplying ammonia for electrical power generation as disclosed by Goetsch.

Goetsch teaches an autothermal process for the decomposition of ammonia gas. It is not seen why one of ordinary skill in the art would substitute the ambient temperature process of Pfister into the process of Goetsch. Goetsch discloses using heat from the hydrogen fuel cell to drive the endothermic ammonia decomposition reaction. As illustrated in Figures 1-4, the reactor for dissociating ammonia and the reaction zone wherein hydrogen is oxidised to provide the heat for the ammonia decomposition are closely connected. Substituting Pfister's ambient temperature decomposition process into Goetsch would not provide the present invention. It is not seen what

would result. If the storage device of Pfister were substituted for the reaction chamber of Goetsch, no reaction would take place.

Neither Pfister nor Goetsch disclose a combustion heating device for heating the metal salts to release ammonia. Therefore, the combination of Goetsch et al. and Pfister et al. does not lead one of ordinary skill in the art to the presently claimed apparatus or method. Applicants submit that, to their knowledge, nowhere in the prior art has a combustion device been disclosed for use as a heating means for desorbing (releasing) ammonia from a metal ammine salt.

The examiner stated that Goetsch teaches that a portion of the hydrogen produced is combusted to produce heat to run the ammonia decomposition reaction and that ammonia oxidation also takes place during hydrogen combustion. However, that is not a teaching or suggest to use combustion heating to release ammonia from a solid ammonia storage material. Goetsch discloses only that the heat of oxidizing hydrogen is used to drive the reaction decomposing ammonia.

Applicants respectfully emphasize that the apparatus of Goetsch does not include an ammonia storage device wherein a solid ammonia storage material is heated so as to desorb ammonia. There is no suggestion, whatsoever, in Goetsch to provide ammonia by desorbing a solid ammonia storage material, particularly using combustion heat.

Thus, it is not seen how the presently claimed invention would have been obvious to one of ordinary skill in the art in view of the combination of Goetsch and Pfister.

Claim 26 is rejected under 35 U.S.C. §103(a) over Goetsch and Pfister in view of Smith et al. (US 2002/0166335; "Smith). Smith is cited for disclosure of a porous support material. Goetsch and Pfister are discussed above. Smith discloses a refrigeration cooling device. Smith fails to make up for the deficiencies of Goetsch and Pfister. Smith also fails to teach or suggest an ammonia storage device comprising an ammonia absorbing and releasing metal salt heated by combustion heating, as claimed herein.

Thus, it is not seen how the presently claimed invention would have been obvious to one of ordinary skill in the art in view of the combination of Goetsch, Pfister and Smith.

Claim 27 is rejected under 35 U.S.C. §103(a) over Goetsch and Pfister in view of Tabor et al. (*sic*; Shomphe et al.) (US 3,423,574; “Tabor”). Goetsch and Pfister are discussed above. Tabor discloses an electrical resistance heating pad. Tabor also fails to make up for the deficiencies of Goetsch and Pfister. Tabor also fails to teach or suggest an ammonia storage device comprising an ammonia absorbing and releasing metal salt heated by combustion heating, as claimed herein.

Thus, it is not seen how the presently claimed invention would have been obvious to one of ordinary skill in the art in view of the combination of Goetsch, Pfister and Tabor.

Claims 29, 30 and 40-42 are rejected under 35 U.S.C. §103(a) over Goetsch and Pfister in view of Holladay et al., “Microfuel processor for use in a miniture power supply,” Journal of Power Sources, 108 (2002) (“Holladay”). Goetsch and Pfister are discussed above. As aforesaid, neither of these, nor their combination disclose or suggest a solid ammonia storage material is heated by combustion heating so as to desorb ammonia. Although Holladay discloses a microscale fuel reformer and a miniature fuel cell, it is not seen how one of ordinary skill in the art would have combined these references to have arrived at the present invention. There is no suggestion in the combination of references for a microscaled ammonia storage device comprising an ammonia absorbing and releasing metal salt heated by combustion heating so as to desorb ammonia.

Thus, it is not seen how the presently claimed invention would have been obvious to one of ordinary skill in the art in view of the combination of Goetsch, Pfister and Holladay.

Claims 33 and 34 are rejected under 35 U.S.C. §103(a) over Goetsch and Pfister in view of Mao et al. (US 2003/0104936). Goetsch and Pfister are discussed above. Mao discloses an unsupported nanoparticle catalyst. Mao also fails to teach or suggest a solid ammonia storage

material is heated by combustion heating so as to desorb ammonia, as claimed herein.

Thus, it is not seen how the presently claimed invention would have been obvious to one of ordinary skill in the art in view of the combination of Goetsch, Pfister and Mao.

The Examiner contends that Goetsch needs a source of ammonia and Pfister provides a source of ammonia. However, Pfister teaches to desorb the ammonia at ambient temperature using microwave energy. No combustion heating is suggested for desorbing ammonia from the solid material by either Pfister, or by Goetsch or by their combination.

Applicants respectfully submit that the Examiner has used Applicants invention as a road map to fit together prior art pieces of information to attempt to provide Applicants invention. As discussed above, the cited prior art fails to teach or suggest Applicants claimed invention.

If for any reason a fee is required, a fee paid is inadequate or credit is owed for any excess fee paid, the Commissioner is hereby authorized and requested to charge Deposit Account No. 04-1105.

In view of the above amendment, applicant believes the pending application is in condition for allowance.

Dated: September 20, 2011

Respectfully submitted,

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